Frequency, Wavelength & Propagation

Prepared by:

WD8PUO

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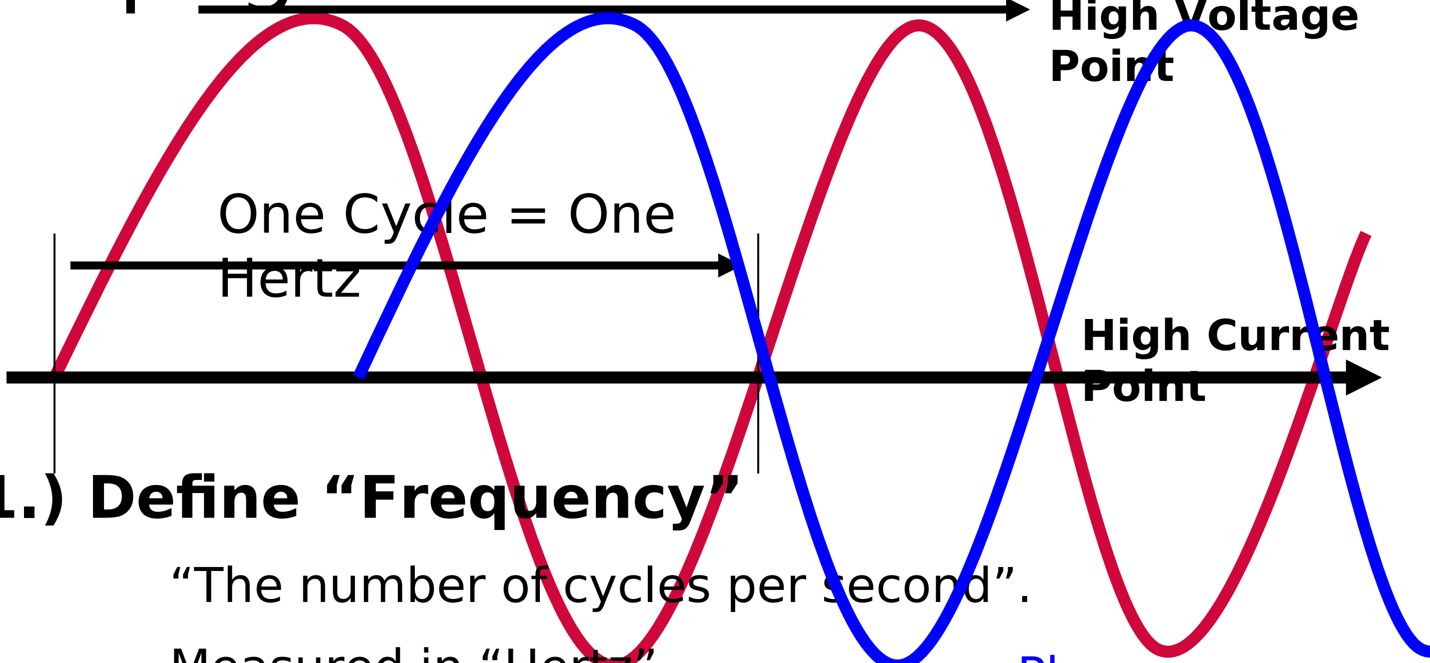
A Course for: Technician & General Class



1.) Define "Frequency"

"The number of cycles per second".

Measured in "Hertz".

Radio Frequency begins above 20,000 Hertz.

2.) Define "Wavelength"

"The distance traveled in one

Measured in "Meters".

3.) Speed of Light

300,000,000 meters per seco

Note: Wavelength decreases as frequency increases. The frequency of the 2-meter band is 144 MHz., the 160

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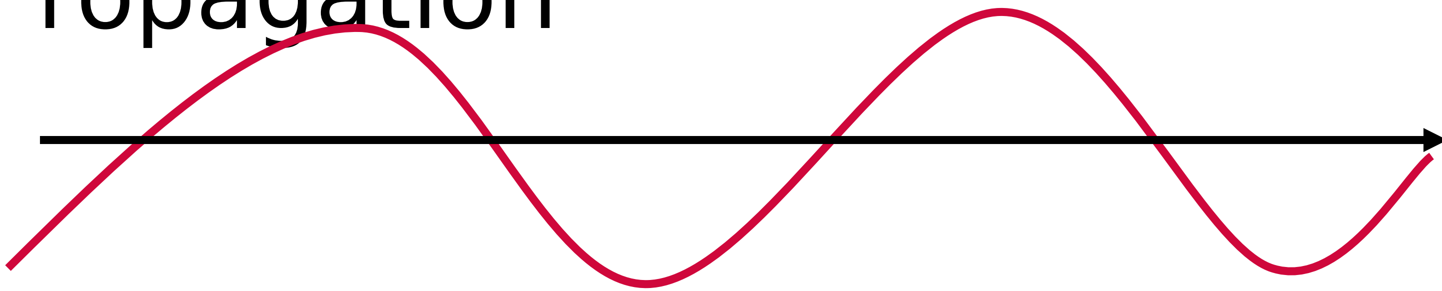

$$\textbf{Wavelength } (\lambda) = \frac{\text{Speed of Light: 300,000,000 m/s}}{\text{Frequency in Hertz}}$$

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Note:

The higher the frequency, the shorter distance in Meters!

Wavelength is referred to as a "BAND", i.e., the 40 Meter Band

Example:	*Answer:*
7,125,000	*40 Meters*
3,725,000	*80 Meters*
21,150,0	*15 Meters*

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International System of Metric

Prefix	Symbol	Multiplication Factor
Giga	G	10(9) = 1,000,000,000
Mega	M	10(6) = 1,000,000
Kilo	k	10(3) = 1,000
Hecto	h	10(2) = 100
Deca	da	10(1) = 1
0		
Deci	d	10(-1) = .1
Centi	c	10(-2) = .01
Milli	m	10(-3) = .001
Micro	u	10(-6) = .000001
Nano	n	10(-9) = .000000001
Pico	p	10(-12)=.000000000001

Examples:

3,750,000 Hz = 3750 KHz = 3.75MHz

7,240,000 Hz = 7240 KHz = 7.24MHz

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"MUF" – Maximum Usable Frequency

Frequency	Day Distance	Night Distance
160 Meters (1.8 MHz)	Closed	0-400 Miles
80 Meters (3.5 MHz)	0-300 Miles (Closed)	0-800 Miles
40 Meters (7.1 MHz)	0-600 Miles	0-1500 Miles
30 Meters (10.0 MHz)	0-800 Miles	0-1700 Miles
20 Meters (14.2MHz)	0-1000 Miles	0-2,200 Miles
17 Meters (18.15MHz)	0-1200 Miles	0-2,200 Miles
15 Meters (21.0MHz)	0-1500 Miles	Closed
12 Meters	0-1700 Miles	Closed

- Flutter on a signal is a sign that MUF has likely been obtained.

Frequency Privileges – General

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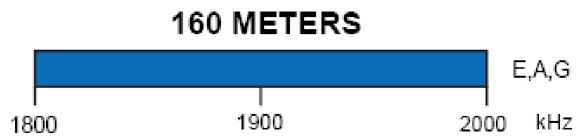
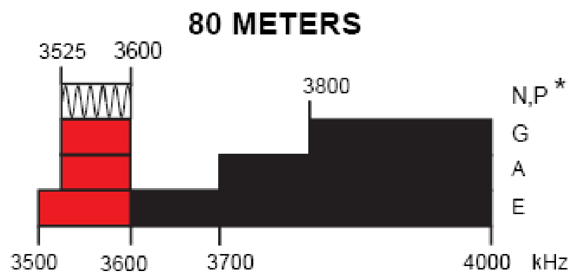
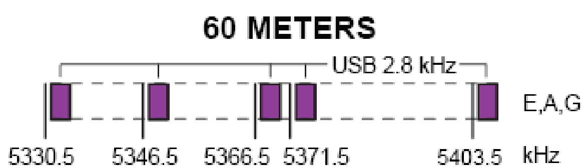
A band plan is a voluntary Guideline beyond FCC Regulations.

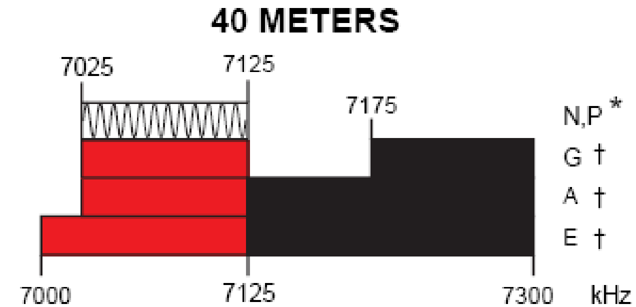


Amateur stations operating at 1900-2000 kHz must not cause harmful interference to the radiolocation service and are afforded no protection from radiolocation operations.

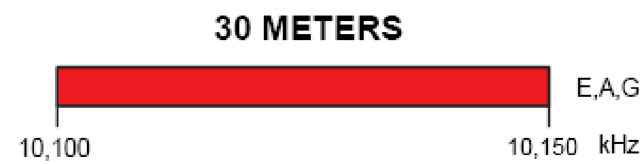




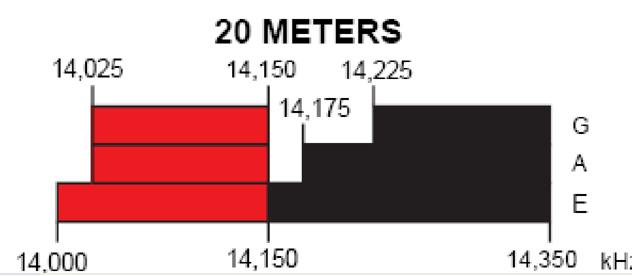
General, Advanced, and Amateur Extra licensees may use the following five channels on a secondary basis with a maximum effective radiated power of 50 W PEP relative to a half wave dipole. Only upper sideband suppressed carrier voice transmissions may be used. The frequencies are 5330.5, 5346.5, 5366.5, 5371.5 and 5403.5 kHz. The occupied bandwidth is limited to 2.8 kHz centered on 5332, 5348, 5368, 5373, and 5405 kHz respectively.



† Phone and Image modes are permitted between 7075 and 7100 kHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11). Novice and Technician Plus licensees outside ITU Region 2 may use CW only between 7025 and 7075 kHz. See Section 97.301(e). These exemptions do not apply to stations in the continental US.



Maximum power on 30 meters is 200 watts PEP output.
Amateurs must avoid interference to the fixed service outside the US.



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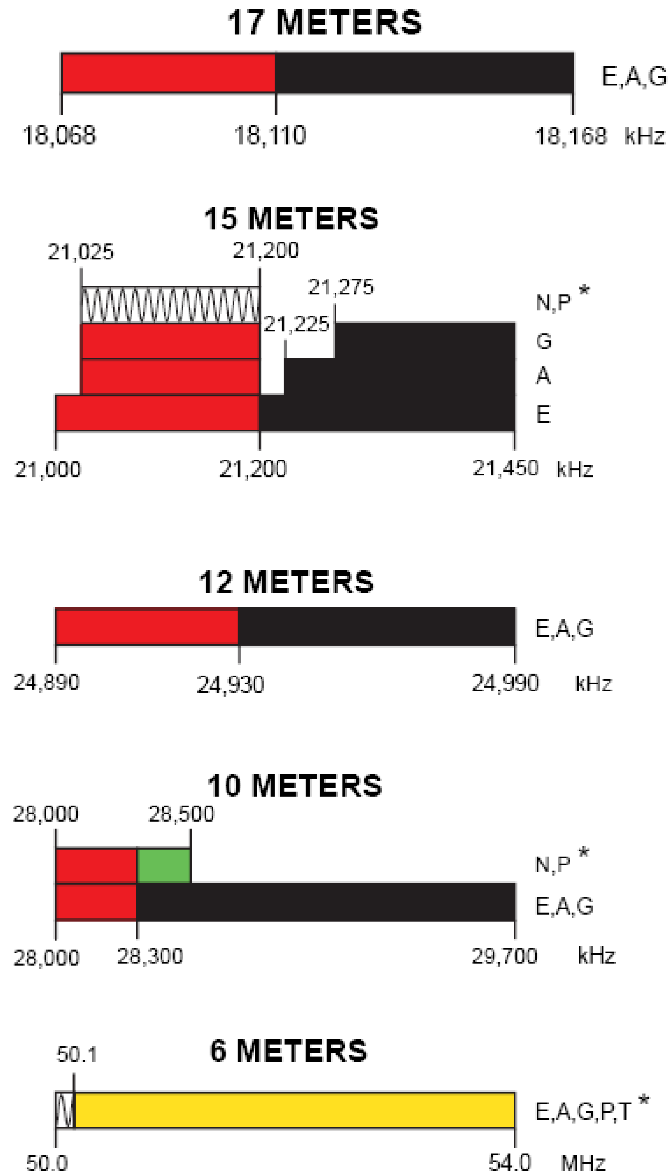

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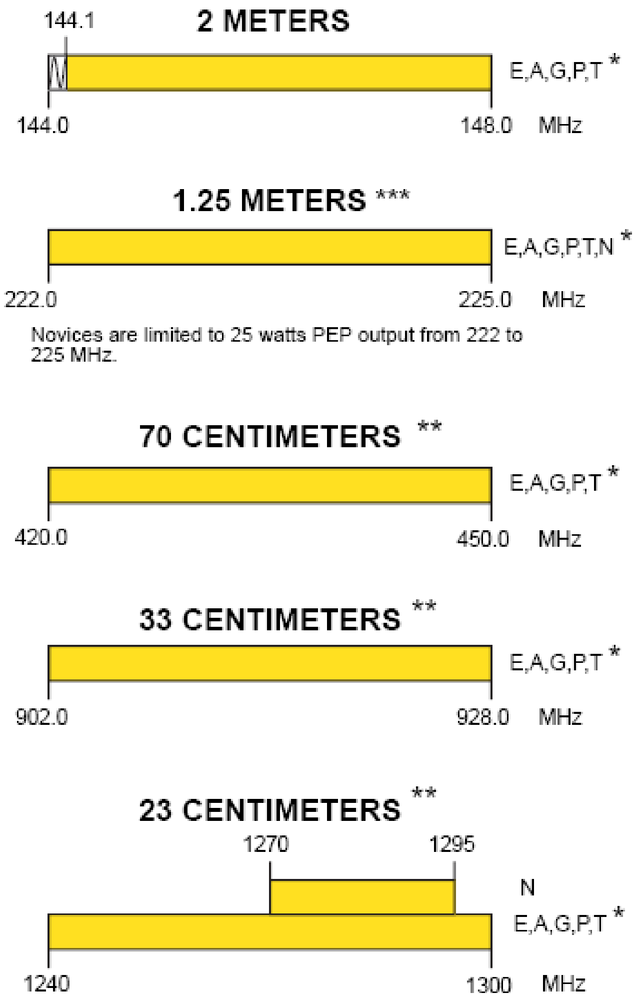

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Propagation

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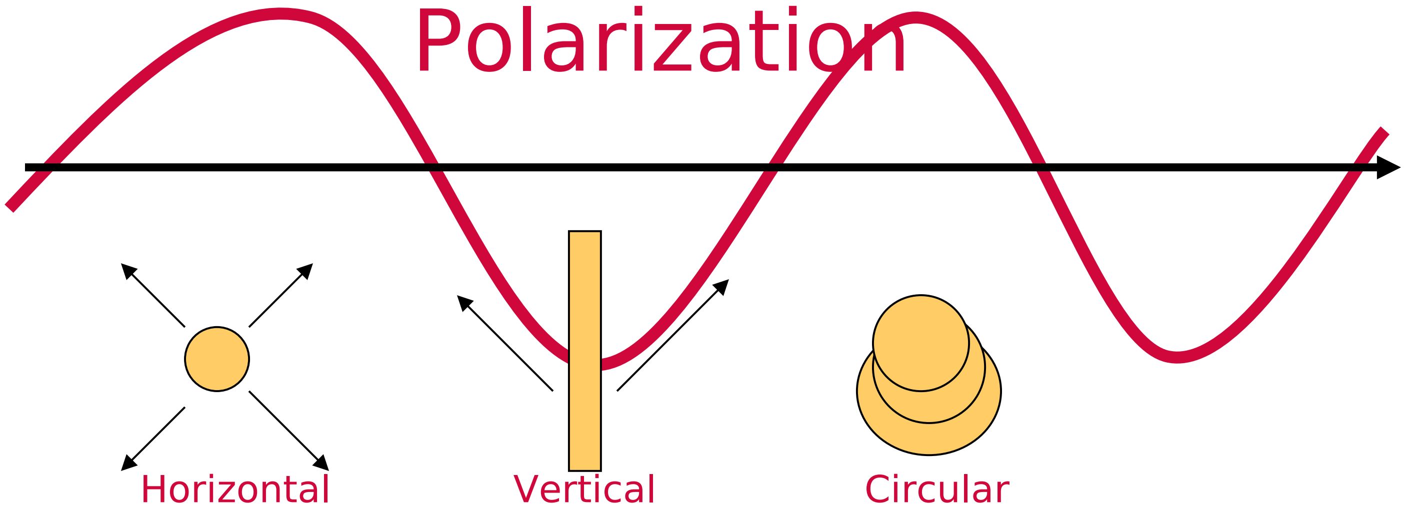

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All Radio Frequency (RF) Signals are Polarized In Free Space...

- Vertical - Produced By Vertically Polarized Antennas.
- Horizontal - Produced By Horizontally Polarized Antenna such as a wire dipole.
- Elliptical – "Faraday Rotation" *The gradual rotation of a linear signal in free space.*
- Circular - *Used In Space Communications*

Propagation – Bending RF Waves

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Reflection – Occurs at the boundary between materials of differing dielectric constant. Example: light reflects off a window pane.

Refraction - Is the bending of a ray as it passes from one medium to another at an angle. Example: the appearance of bending of a straight stick, where it is made to enter water at an angle. Refraction is common between <u>*tropospheric*</u> air masses.

Diffraction - An example would be light over a solid wall prevents darkness on the far side from the light source. It is a result of RF waves interfering with one-another.

Note: These three phenomenon are usually

Propagation Types: *The Ground Wave*

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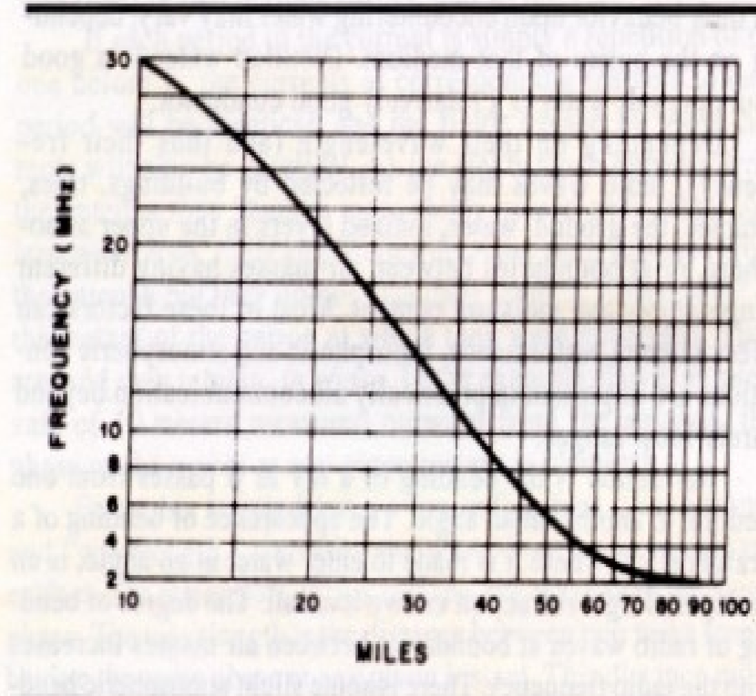
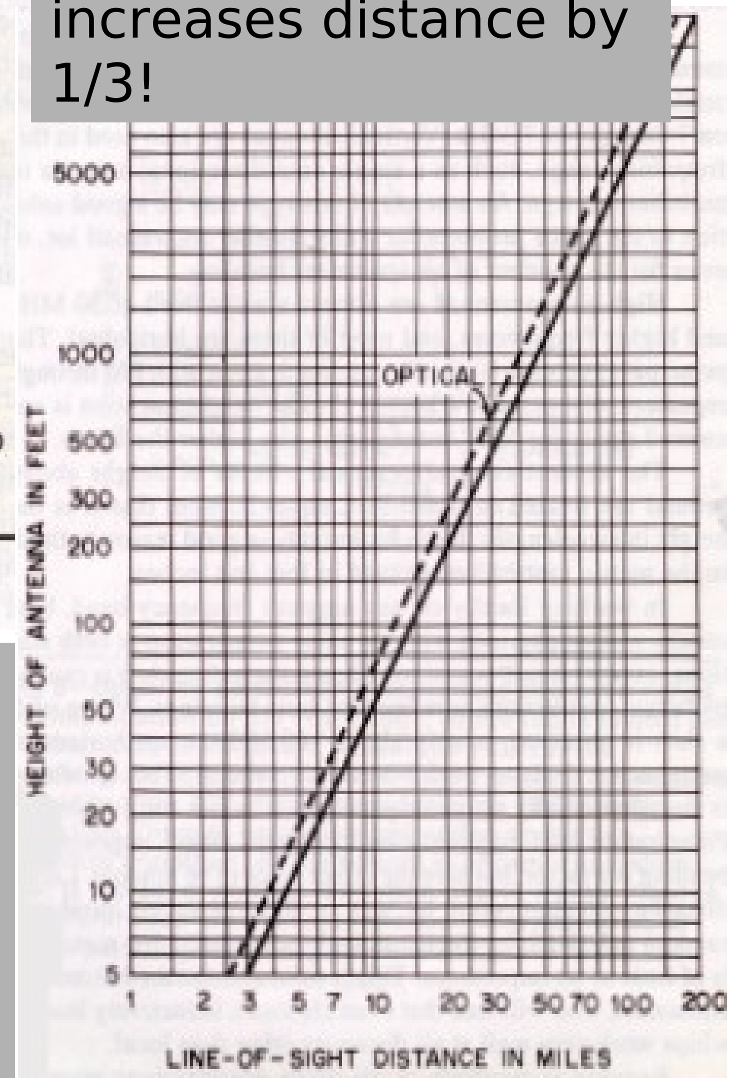


Fig 3—Typical HF ground-wave range as a function of frequency.

Antenna height plays a major factor in ground wave propagation.

High transmitting and receiving antennas allows an RF signal to “see over”

Antenna height obviously gets you only so far…scatter increases distance by 1/3!



Propagation: VHF Ground Wave Repeaters

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At the VHF frequency spectrum (typically 50 MHz to 440 MHz) one popular method of extending ground wave propagation is to make use of repeaters.

A repeater receives your transmitted signal, and retransmits it on a different frequency. This difference in frequency is referred to as the “Off-Set”. Off-sets are usually above (+) or below (-) the listening frequency. Obviously, a transceiver must be able to transmit and receive on different frequencies.

Repeaters typically make use of a (PLL)“tone-burst” to allow the repeater to differentiate between signals that should be retransmitted, and those signals that should

Propagation: UHF Tropospheric Ducting

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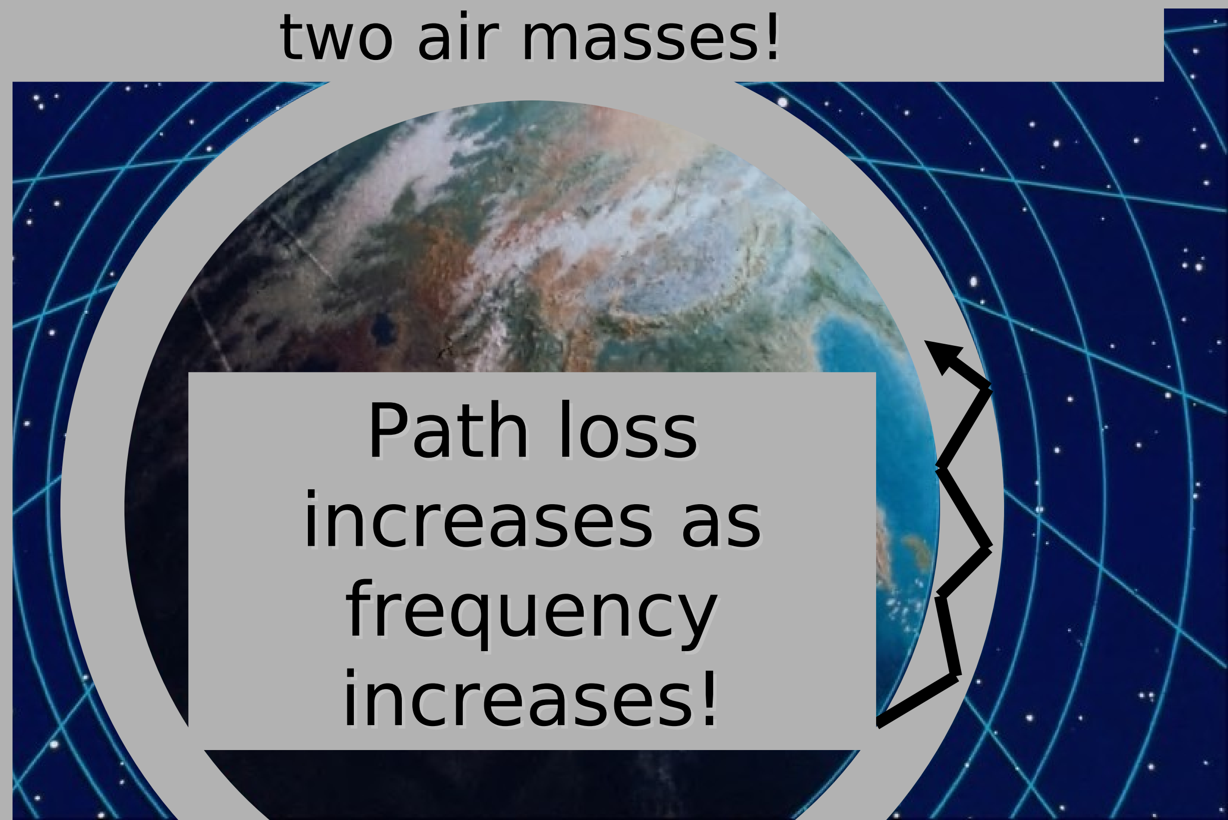
A UHF phenomenon (above 144 MHz) that occurs when a stable high pressure system of warm stratified air moves over cooler moist air (A Temperature Inversion. The typical distance is 200 – 400 miles. Common regions that experience this propagation are the Southern California Coast, The gulf c

The RF signal is “ducted” between two air masses!

Occurs Within The First 37



Path loss increases as frequency increases!

Propagation Types: VHF Satellite

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In the VHF spectrum above 50 MHz, one method of DX (long distance) communications is reflecting a signal off the moon and back to earth. This form of prop-agation typically requires a signal to be of circular polarization (A High Gain Yagi Array). Phase shifts are a common problem that results in signal attenuation (Extreme Path Loss). (Higher power is typically required, especially when the satellite is low to the horizon. The satellite must be in view of both stations for communication

A Man-made Satellite Is Nothing More Than An Orbiting Repeate

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Propagation: HF Sky-Wave Skip

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High Frequency (HF) skip propagation is caused by the sun's ultraviolet and x-ray radiation energizing the IONOSPHERE. The electrons at the D and E layers are quite dense and absorb radio signals as heat energy. The F1 and F2 layers, being less dense, reflect back the signal earth. The best DX is after sunset!

D-LAYER

The lowest known ionized region is 37 – 57 miles above earth. It mostly absorbs long-wave signals during day.

E-LAYER

62-71 miles above the earth, it usually absorbs long-wave signals

Gray-Line Propagation

Scatter

Skip Zone

2,500 Miles Max. for "F" Layer, 1,200 Miles Max. for "E" Layer.

*The "Critical Angle" is the highest take-off angle that will reflect a signal back to earth.

D E F1 F2

F1/F2 LAYERS

At night, the D and E layers dissipate, and the F1 & F2 layers merge. The F layers are responsible

Propagation: HF Sky-Wave Skip

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Other Propagation Information Students Need To Know…

- "Scatter" is usually produced in the "Skip Zone" at the Maximum Usable Frequency" (MUF), and is characterized by its weak signal strength and fluttery or distorted sound. A band's MUF can be determined by listening to regional beacons.
- The number of sunspots on the sun determine how ionized the Ionosphere becomes. The number of sunspots increases and decreases on an 11-year cycle. When the sunspot cycle is low, the 160 – 40 meter bands are quiet and useful for medium range communications, while the bands above 20 MHz are usually dead. When sunspot activity is high, the low bands are very noisy, but the bands above 20MHz are very active for DX! "Band Openings" usually occur on a 28 day cycle.
- If you are on an HF band, and a sudden ionospheric disturbance arises, try a higher frequency to avoid the noise.
- It takes 8 minutes for increased ultraviolet and x-ray radiation from solar flares to affect radio-wave propagation on the earth.
- Solar Flux is the radio energy emitted by the sun. The "Solar Flux Index" is the measure of solar activity that is taken at a specific frequency.

Propagation: *Demonstrations*

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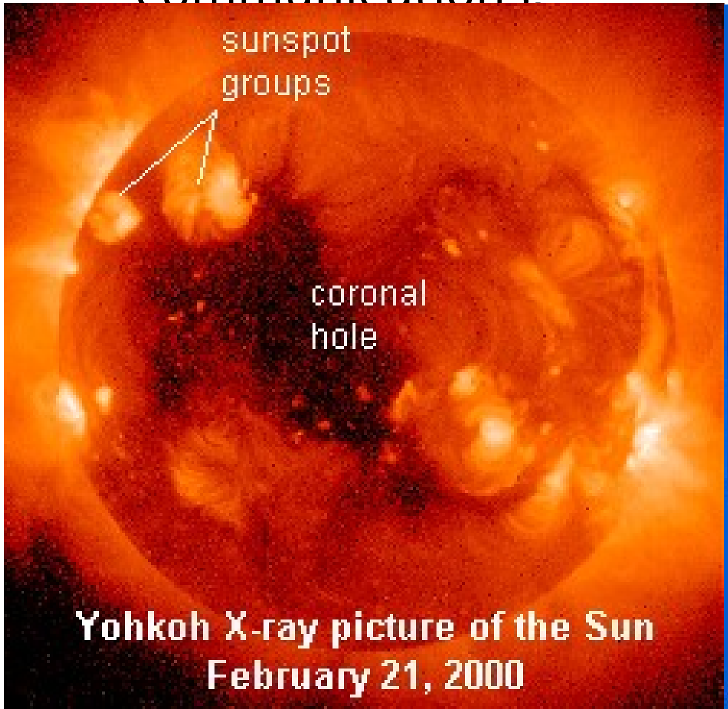
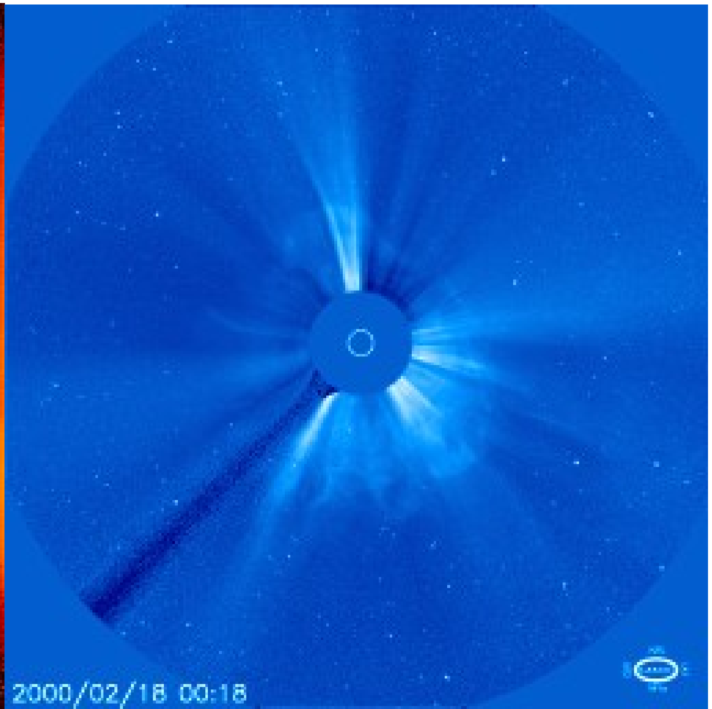
Demonstrate the various HF bands, making QSO's where possible. Note the distances communicated on the various bands for the time of day. Note if bands are closed. Discuss how the time of day and ionosphere are impacting communications.





Ham Radio

Propagation: *Demonstrations*

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End of Lesson 2